Storage Ring Diagnostics &
Beam Position Monitor System Performance

- BPM System overview and performance specifications
- Experience with Beam Position Limits Detectors (BPLD’s)
- BPM systematic effects and compensation
- R&D and upgrade plans for the BPM system
- Overall Group R&D plans
- Photon diagnostics status and plans

Storage Ring
Beam Position Monitor System Performance

- 360 stations, four button-type pick-up electrodes
  AM/PM conversion, in-tunnel differencing
- Information used as input to computer orbit correction algorithm
- Supports real-time closed orbit feedback system
- Data used for beam position limits detector (BPLD) interlock

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Beam Position Monitor System Performance (cont'd)

Beam position monitor system features

- 60-Hz EPICS data acquisition (slow beam history)
- 271-kHz data acquisition and up to 32000 sample deep FIFO memory (fast beam history)
- Up to 2048 sample real-time boxcar averager (upstream of EPICS)
- EPICS weighted average of boxcar averager outputs (for sub-micron work)
- Real-time interface to DSP-based closed orbit feedback system
- Built-in test feature for testing without beam
- Single bunch (or cluster) capability effectively increases dynamic range of system, e.g., since performance with four clusters with 40-100 mA total current is identical with that for a single cluster of 10-25 mA.

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Beam Position Monitor System Performance (cont'd)

Orbit stability specifications

4.5 microns rms vertical
17 microns rms horizontal

Beam position monitor performance requirements

Absolute accuracy:

200 microns rms wrt adjacent quad centers

Achieved:

approx. 50 micron quad center determination
using quad steering as diagnostic

Resolution:

<< 4.5 microns "dc" - 100 Hz

Achieved:

0.1 micron-mA/sqrt(Hz)

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Beam Position Monitor System Performance (cont'd)

Interface to closed orbit feedback system

Turn-by-turn data (12 bits) is supplied from up to 8 of the 9 BPMs per sector for two adjacent sectors to the local closed orbit feedback system processing crate, via the memory scanner modules. Digital filtering and matrix column multiplication takes place at a 1-kS/sec rate for adjustment of local steering correctors. Real-time transmission of data around the ring allows local correction employing global orbit data.

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Beam Position Monitor System Performance (cont'd)

Interface to beam position limits detectors (BPLDs)

Individual insertion device sources have intensities great enough to damage storage ring vacuum components if accidentally mis-steered. A digital circuit monitors the data from selected BPMs straddling the source point, removing a heartbeat signal to the storage ring machine protection system when a missteering condition is detected.

Fast beam history capability of BPM system allows comprehensive post-mortem analysis. A majority of MPS related "downtime" results from real beam motions.

Work continues on a design for a stand alone circuit that will make use of the "old P1" button pick-ups, whose BPM electronics have been relocated to the small gap insertion device vacuum chamber pickups.

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Beam Position Monitor System Performance (cont'd)

Systematic AM/PM convertor intensity dependence

During the course of a user run, unacceptably large x-ray beam motions were observed with computer orbit correction running continuously. A malfunctioning rf beam position monitor was suspected andremoved from the correction algorithm. Subsequent stability on the beamline in question was improved.

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Beam Position Monitor System Performance (cont'd)

Systematic AM/PM convertor intensity dependence (cont'd)

Subsequently, an intensive machine studies period (10/1 through 10/6/96) was dedicated to the study of BPM systematics and generation and implementation of work-around strategies.

Conclusions of these studies were:

- The effect was minimized when running at the highest signal levels in an electronically balanced configuration, i.e., with the position readback near zero in both planes.
- The effect is dominated by the quality of the in-tunnel filter / comparator units. It was demonstrated that stable operation could be achieved by selection of a good filter / comparator, keeping intensity-dependent variation to less than +- 5 microns in the range of beam current from 40 to 100 mA.
- Use of a severely underdetermined algorithm, namely SVD, that retained only a small number of eigenvalues (20) while using a large number of beam position monitors was found to minimize the effects of individual bpm variations on the true DC orbit.
- A "de-spiking" algorithm was put in place to catch BPMs that develop "large" offsets (e.g. > 10 microns) with time, which replaced their value by the average of neighboring units.

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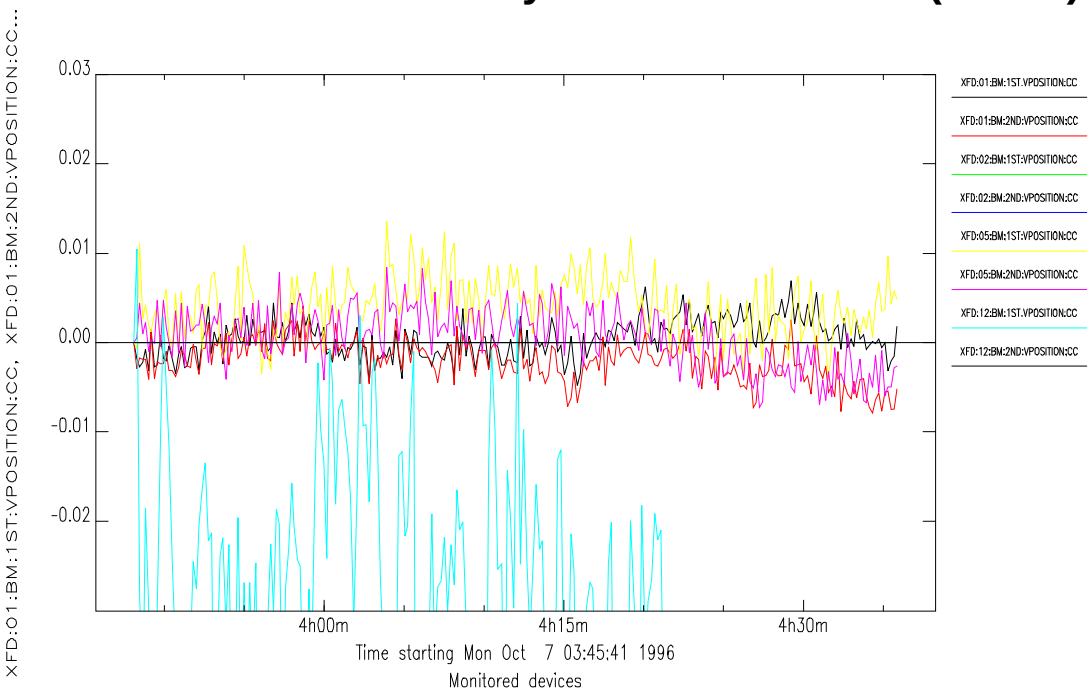
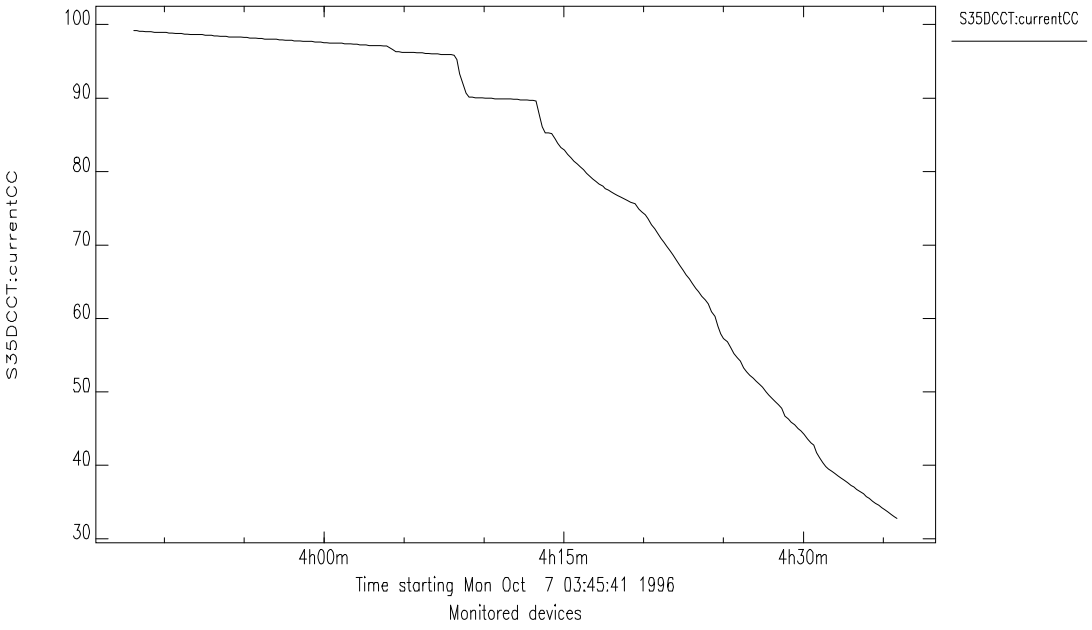
Beam Position Monitor System Performance (cont'd)





Variation of vertical bending magnet line x-bpm's with stored beam current. Orbit correction with de-spiking algorithm is on.

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Future R&D and upgrade plans for BPM related systems

- Near Term (six weeks time frame)

Understand in detail the mechanism causing the intensity dependence (filter / comparator phase, gain errors, bandpass filter characteristic).

Develop detailed calibration / repair procedures to minimize this systematic effect.

- Intermediate Term (six month time frame)

Consider procurement of upgraded in-tunnel units for 84 locations required for precise source point control to assure 4.5 micron rms specification is met for all operating conditions.

Pursue present collaborative effort with XFD (XAXSTF) to understand and implement x-ray beam position monitors and their use in orbit correction algorithms, in combination with RF BPM's.

- Long Term (> six months)

Procurement and commissioning of upgraded stand-alone BPLD's (FY97)

Upgrade BPM triggering to improve reliability under wide variety of operating conditions (FY97, 98)

Support closed orbit feedback system long-term goals

Pursue sub-micron stability for higher brightness operation

Diagnostics Group

Future R&D and upgrade plans for other systems

- Booster-to-Storage ring (BTS) line current monitor and position monitor upgrade in support of top-up operation (FY97, 98)
- Storage ring bunch current monitor for improved control of fill pattern (FY97)
- Fast (i.e. multibunch instability) damper system (FY97, 98)
- Low energy undulator test line intensity and position measurement diagnostics. Objective is few-micron single pass capability (FY97,98)
- Low energy undulator test line photon diagnostics
- Completion of storage ring sector 35 bending magnet and insertion device beamlines (FY97, 98)
- Refined system observation and routine maintenance plans to attain division reliability and availability goals, i.e. > 100 hours mean time to beam loss, primarily from BPLD or BPM-related failures, and > 90% overall x-ray beam availability